DEVELOPMENT OF ISOHYET MAP USING INVERSE DISTANCE WEIGHTING AND ORDINARY KRIGING METHODS FOR KLANG RIVER BASIN

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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Lembangan Sungai Klang merupakan salah satu lembangan paling penting di negeri Selangor. Ia meliputi Wilayah Persekutuan Kuala Lumpur, Hulu Langat, Gombak, Petaling dan Klang. Lembangan ini mengalami perkembangan ekonomi yang pesat di Malaysia. Oleh itu, pengetahuan mengenai taburan hujan di lembangan ini sangat berguna untuk pengurusan bencana dan pengurusan sumber air. Kaedah interpolasi spatial sering digunakan untuk mencari nilai anggaran parameter meteorologi. Dalam kajian ini, data hujan dibahagikan kepada hujan purat bulanan dan tahunan (sebelum dan selepas 2000). Peta isohyet dihasilkan menggunakan Inverse Distance Weighting (IDW) dan Ordinary Kriging (OK) melalui ArcGIS Geostatistical Analyst. Kaedah-kaedah ini akan dibandingkan dan dinilai menggunakan pengesahan bersilang. Dari analisis ini, Ordinary Kriging (OK) adalah kaedah yang paling bagus untuk lembangan sungai Klang kerana is mempunyai perbezaan nilai anggaran dan ralat yang kecil dan kecenderungan pusat yang lebih besar. Peta isohyet yang dihasilkan oleh Ordinary Kriging (OK) kemudian akan digunakan untuk menganalisis kesan perubahan iklim di lembangan ini. Melalui tahunan peta isohyet, ia dapat diperhatikan bahawa tahunan hujan purata di lembangan ini telah meningkat selepas ke 20 abad. Kawasan yang paling kering didapati di Klang, Selangor yang terletak di bahagian hilir lembangan. Purata hujan turun kurang berbanding sebelum ini disebabkan oleh pemanasan global. Kawasan ini semakin panas dan menyebabkan kemarau lebih teruk. Sementara itu, kawasan paling basah terletak di Kuala Lumpur. Kuala Lumpur terletak di bahagian tengah tangkapan. Nilai purata hujan semakin meningkat di bandar. Ini disebabkan oleh kesan pulau haba bandar yang mengakibatkan suhu yang lebih tinggi di bandar. Akibatnya, kejadian banjir kilat diramal berlaku selepas dua hingga tiga jam hujan lebat di kawasan ini.

ABSTRACT

Klang river basin is one of the most important basins in Selangor. It covers federal territory of Kuala Lumpur, Hulu Langat, Gombak, Petaling and Klang. This basin experiences the highest economic development in Malaysia. Therefore, appropriate knowledge of rainfall distribution in this basin is very useful for disaster management and water resource management. Spatial interpolation method is a frequent common method to find the estimate values of meteorological parameters. In this study, the rainfall data were classified into monthly and annually average rainfall (before and after 2000) in order to assess the rainfall patterns in the river basin. The isohyet maps were produced using Inverse Distance Weighting (IDW) and Ordinary Kriging (OK) through ArcGIS Geostatistical Analyst. These methods are compared and evaluated using cross validation. From the analysis, Ordinary Kriging (OK) is the most optimum interpolation method over Klang river basin because it has less variation of estimate values, smaller error and greater central tendencies. The isohyet maps generated by Ordinary Kriging then are used to analyze the impact of climate change over this basin. It can be observed that annually average rainfall in this basin had been increased after 20 century. The driest area is found in Klang, Selangor which located at the lowest part of the catchment. The average rainfall had been decreased compare to previous due to global warming effect. The study area becoming hotter and make drought more severe. Meanwhile, the wettest area is located in Kuala Lumpur. Kuala Lumpur is in the middle part of the catchment. The average rainfall had been increased intensely in the city. This is because of the urban heat island effect that results in higher temperature in the city. Consequently, flash flood events may occur after two to three hours of heavy rain in this region.

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LIST OF SYMBOLS

°C	Celsius
Km^2	Kilometre Square
mm	Millimetre
x	Station
Px	Missing Annual Precipitation
m	Missing Station
Nx	Normal Annual Precipitation
P_m	Annual Precipitation Value
n	Number of Stations
$_i$	Index Station
$_n$	Number of Index Station
$\hat{Z}(s_0)$	Prediction Value for Location s_0
$\hat{Z}(s_i)$	Observed Value for Location s_i
N	Total Measured Sample Point Numbers
λ_i	Weight
d_{i0}	Distance Between Prediction and Measured Location
n	Number of Rain Events
Z_i	Observed Value from Position i
$\hat{Z}_i$	Predicted Value from Position i
$\bar{Z}$	Mean Observed Rainfall
A	Area
$\overline{P}$	Average Precipitation

LIST OF ABBREVIATIONS

MMD	Malaysian Meteorological Department
DID	Department of Irrigation and Drainage
IPCC	Intergovernmental Panel on Climate Change
GIS	Geographical Information System
DJF	December January February
JJA	June July August
MAM	March April May
SON	September October November
IDW	Inverse Distance Weighting
OK	Ordinary Kriging
UK	Universal Kriging
S	Spline
TR	Topo to Raster
RHI	Range Height Indicator
WMO	World Meteorological Department
MAE	Mean Absolute Error
RMSE	Root Mean Square Error
SRMSE	Standardized Root Mean Squared Error
G	Goodness of Prediction Measure
ESRI	Environmental Systems Research Institute
LP	Local Polynomial
GP	Global Polynomial
TRMM	Tropical Rainfall Measuring Mission
PBIAS	Percent of Bias

CHAPTER 1

INTRODUCTION

1.1 General

Climate of Malaysia is considered as hot and humid throughout the year due to it located near to the equatorial doldrum area. The average rainfall for Malaysia is around 2500 millimetres a year and its average temperature is 27°C (Mohamed *et al.*, 2014). According to Malaysian Meteorological Department (MMD), consistent periodic changes in the wind flow patterns have distinguished Malaysia climate into four monsoons namely northeast monsoon, southwest monsoon and two shorter periods inter-monsoon seasons. Northeast monsoon started from November until March whereas southwest monsoon usually commences in May or June but ended in September. Inter-monsoon began in March to May and October to mid-November (Fakaruddin *et al.*, 2015).

Climate change has become the hottest debate issue around the world. Malaysia is situated between Pacific Ocean and Indian Ocean. Its climate is influenced by variation of the natural climate associated with both oceans. The knowledge of how natural climate variability to a particular region is significant. This is to understand assess and impact of climate change to a particular region (Fredolin *et al.*, 2012). Flooding is one of the impacts of climate change that can lead a tremendous impact to the financial, environmental or human losses. Department of Irrigation and Drainage (DID) has classified flood in Malaysia into two categorizes which are monsoon flood and flash flood. Recently, Malaysia has encountered several extreme weather events due to the change of climate. These changes can bring serious effects on economic, social, physical or ecological (Hashib *et al.*, 2011). The worst flood event occurred in Malaysia was in the 2014 where more than 200,000 people have been affected and 21 people were killed due to the flood event (Akasah, 2015). Thus, it is critical to understand the characteristic of rainfall in order to presume the effect of rainfall in the evapotranspiration, infiltration and runoff process (Knight *et al.*, 2005).

Klang river basin encompasses some districts in Selangor and also includes federal territory of Kuala Lumpur. This basin has the densest population and is situated in the most developed region in Malaysia. According to Sidek (2016), it is likely to experience the highest economic development in the country with the prediction over 3.6 million of population and with an approximately 5% growth rate per year. Flash flood is the most common geohazard in Kuala Lumpur. After two or three hours of heavy rain, the water level of river in the Kuala Lumpur region could reach its peak discharge. It is a result of unplanned rapid development and major changes of land use at Kuala Lumpur have narrowed certain stretches of the river. It is assumed that during monsoon season 5700 hectares of populated area on the Klang river and its tributaries will be flooded (Gert de Roo, 2004).

The important element in hydrological cycle is precipitation. It controlled water disasters and water supplies (Taesombat and Sriwongsitanon, 2009). Rainfall data is needed by the hydrologist in hydrological modelling process and to estimate terrific precipitation events caused by the global climate change like droughts and floods (Wagner *et al.*, 2012; Jamaludin and Suhaimi, 2013). This is because acquired precise rainfall data is crucial in order to predict the spatial behaviour of the rainfall intensity and its pattern. Due to the topographic variability, rainfall will never distribute evenly through the catchment areas. However, it is impossible to install many rainfall station gauges in the area of study (Jamaludin and Suhaimi, 2013; Taesombat and Sriwongsitanon, 2009). Good interpolation method is required to find the missing values of meteorological parameter (Wijemannage *et al.*, 2016). Several spatial interpolation methods have been introduced in order to estimate the rainfall data in the unsampled locations (Sarann *et al.*, 1997). Estimated actual rainfall over the basin is very useful for prediction of the possibility of flood event happen due to climate change so that flood mitigation and prevention can be carried out as soon as possible (Hao and Chang, 2013; Wijemannage *et al.*, 2016). The rainfall information also helps engineer to design suitable drainage system in the area of study.

1.2 Problem Statement

Climate change has been arisen as one of the major global challenges for whole world. According to The Star Online on 11 June 2017, the temperature different between the region in Kuala Lumpur and its neighbouring rural areas is about 10°C. The hotter temperature caused heavy rainfall happened in urban area that lead to several flash floods whereas less rainfall in suburban area. The effect of urban heat island in the city is due to the rapid development. Flash flood always occurs in Klang Valley after heavy rain. It is the result of rapid urbanisation in the river catchment area which deteriorated the capacity of river. As a result of heavy development, large concentration of runoff flow into the river which exceed the capacity of the river. For instance, flash flood happened in Jalan Bangsar, Jalan Pantai Baharu, Jalan Pudu and Jalan Semantan had caused more than 100 vehicles trapped in Klang Valley on 12 May 2016.

Figure 1.1 Flash flood in Jalan Tuanku Abdul Halim
Source: The Star Online (2016)

Accurate and effective rainfall data is vital for hydrologist with regard to create a reliable isohyet map that describes the spatial behaviour of rainfall intensity and its pattern. The maps are developed via Geographical Information System (GIS) software with precise data of annual rainfall and seasonal rainfall. Acquired precise isohyet map can help to detect the location of floodplain. It would aid Malaysian Meteorological Department (MMD) to made early preparation for flood disaster planning such as issues early warning to the local residents. It also assisted hydrologist in hydrological analysis and water resources management. Several spatial interpolation methods are used to

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